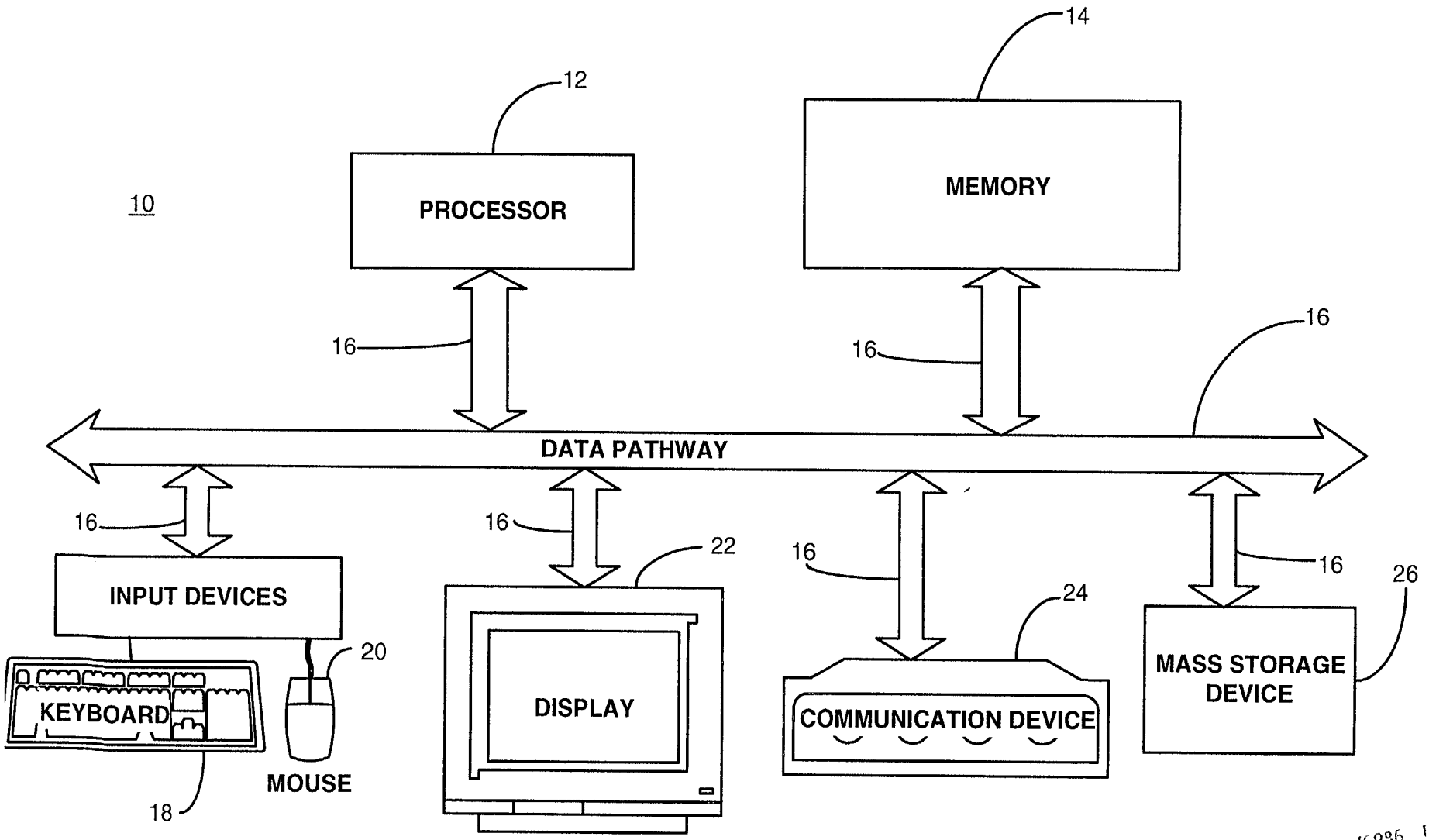
Fig. 1



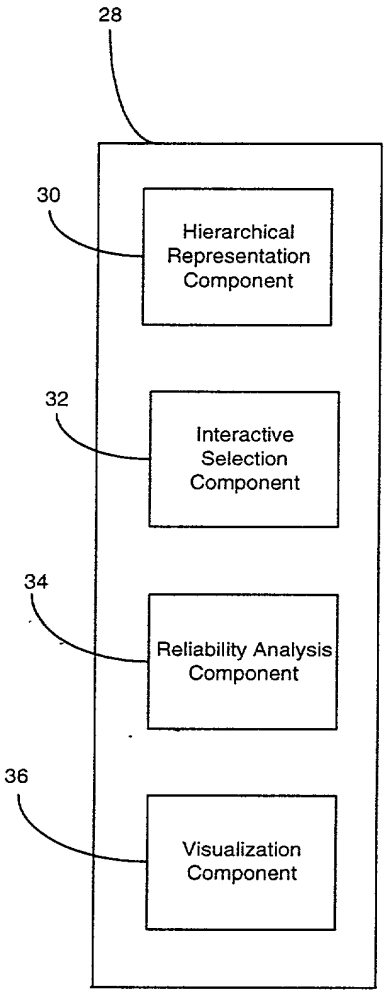

28
30
Hierarchical Representation Component
32
Interactive Selection Component
34
Reliability Analysis Component
36
Visualization Component

Fig. 2

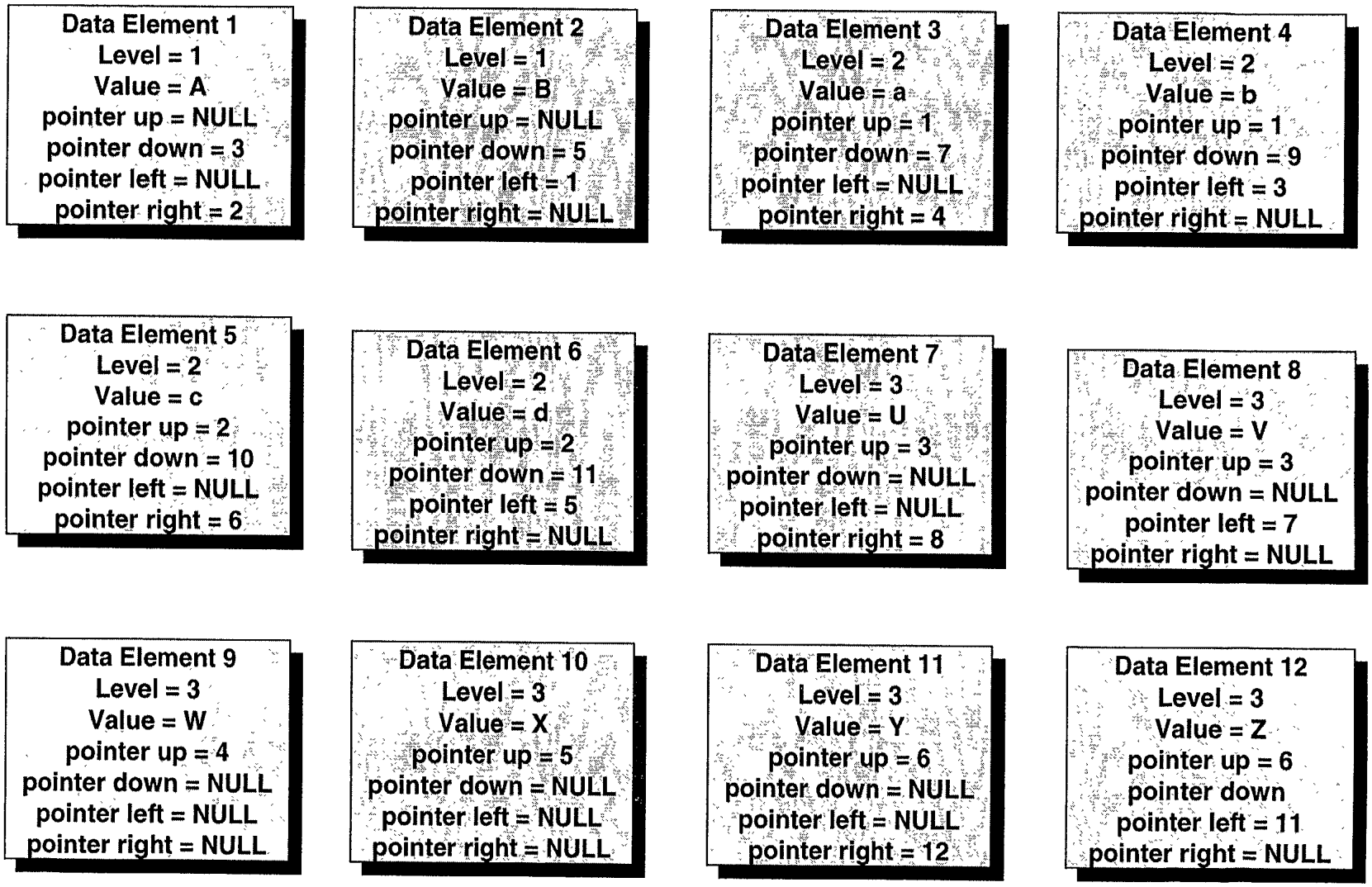


Fig. 3

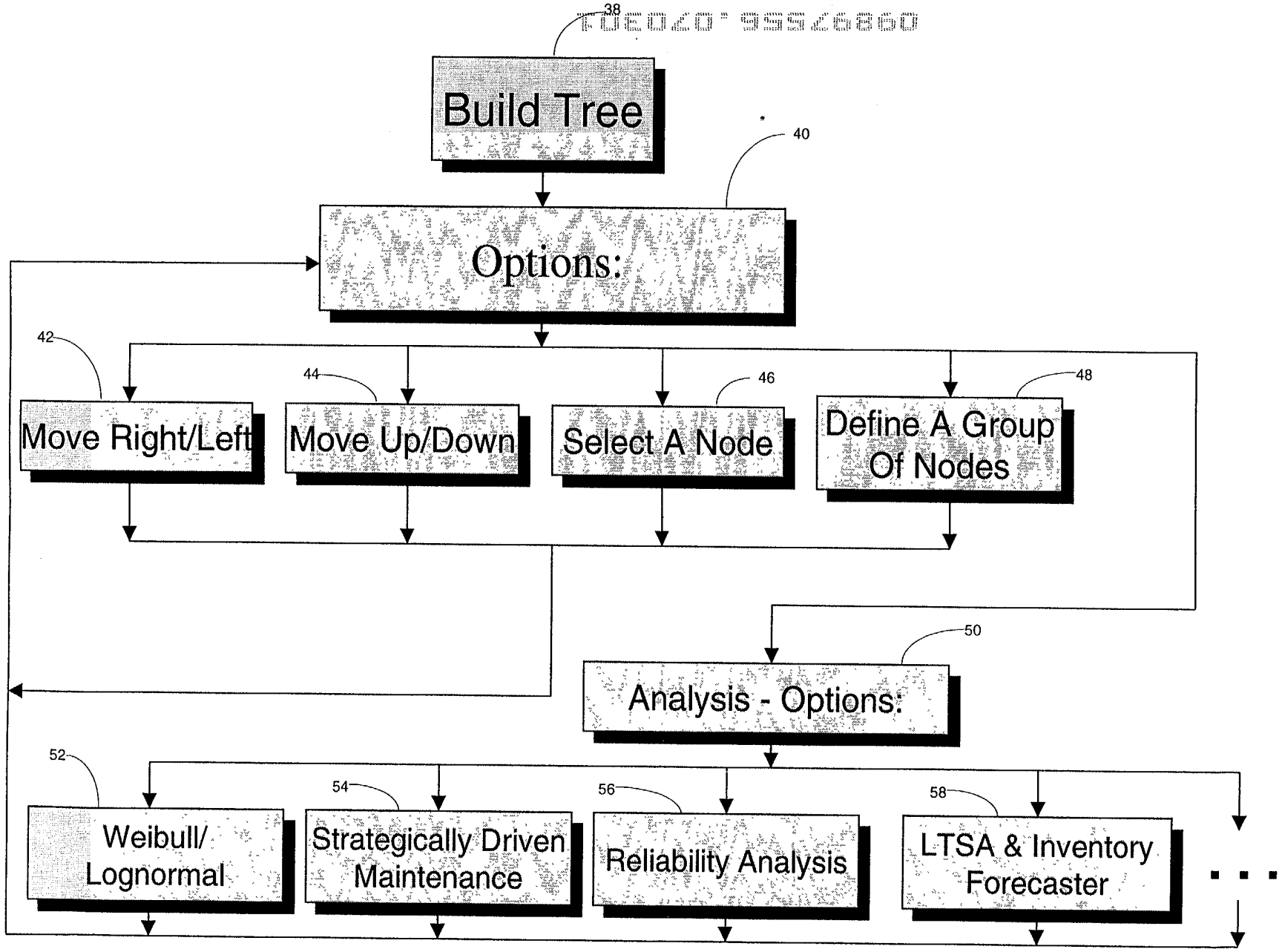

38
Build Tree
40
Options:
42
Move Right/Left
44
Move Up/Down
46
Select A Node
48
Define A Group Of Nodes
50
Analysis - Options:
52
Weibull/ Lognormal
54
Strategically Driven Maintenance
56
Reliability Analysis
58
LTSA & Inventory Forecaster

Fig. 4

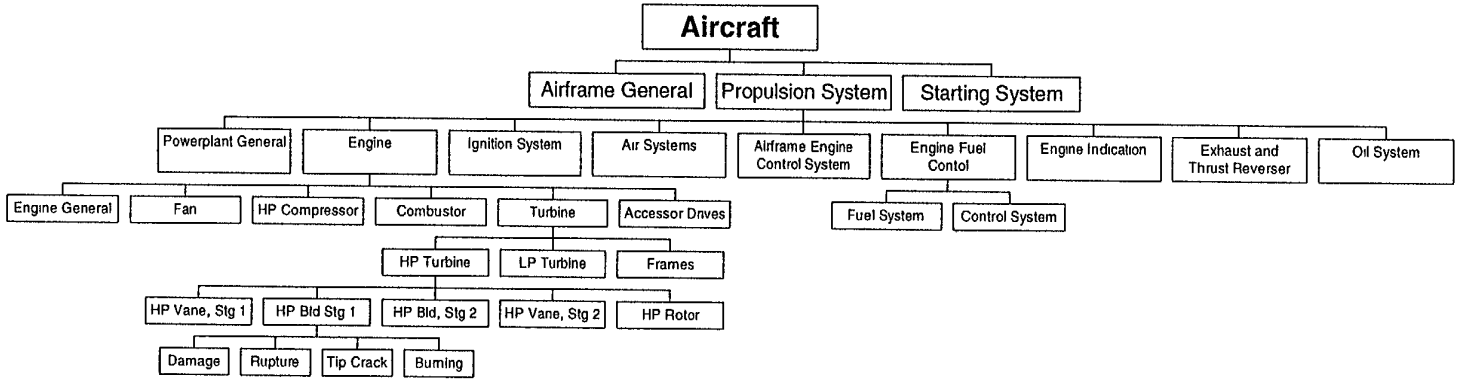


Fig. 5

Moving Right/Left

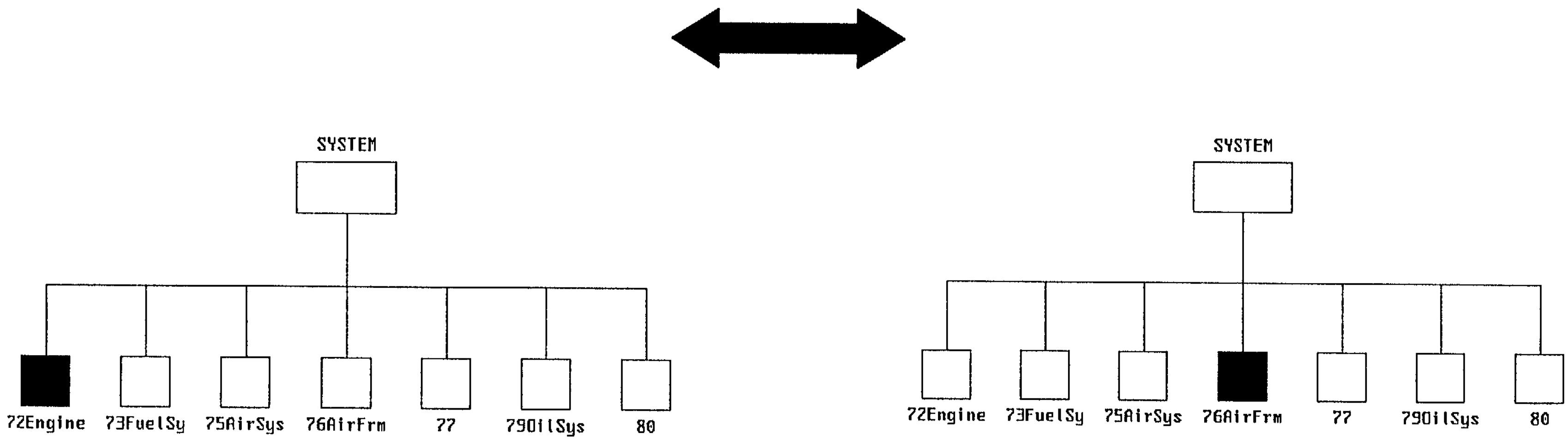
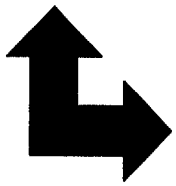


Fig. 6a

Moving
Up/
Down



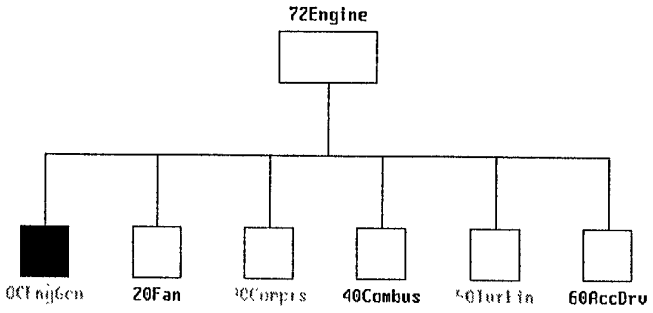


Fig. 6b

Selecting Nodes

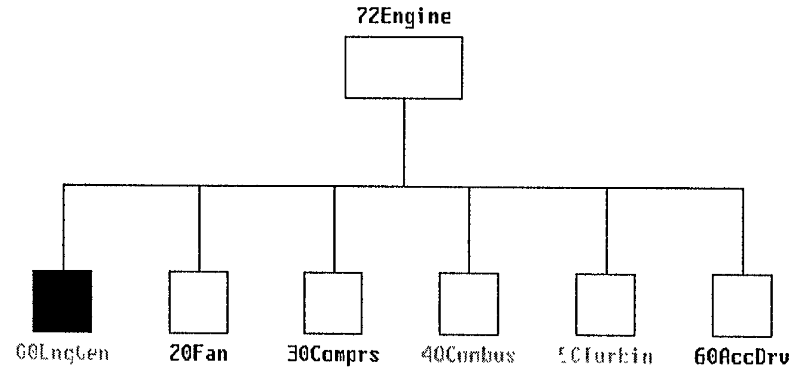
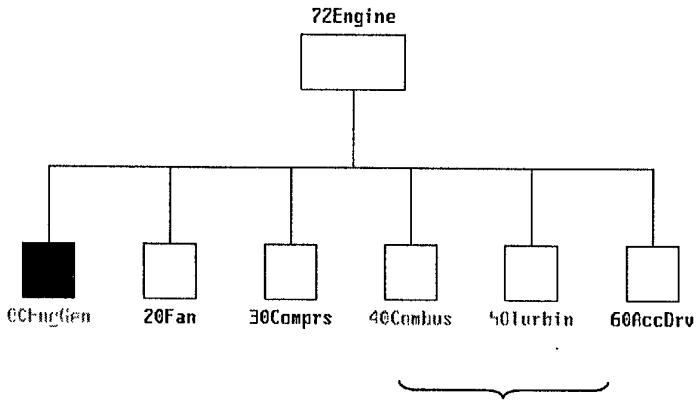


Fig. 6c



Defining A Group

Fig. 6d

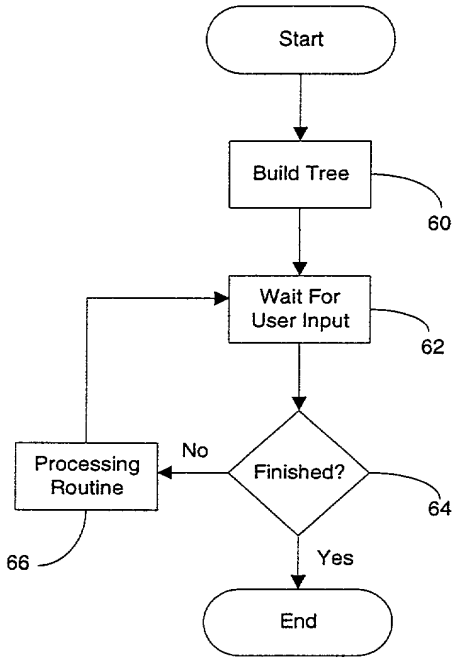

Start
Build Tree
60
Wait For User Input
62
Finished?
64
No
Processing Routine
66
Yes
End

Fig. 7

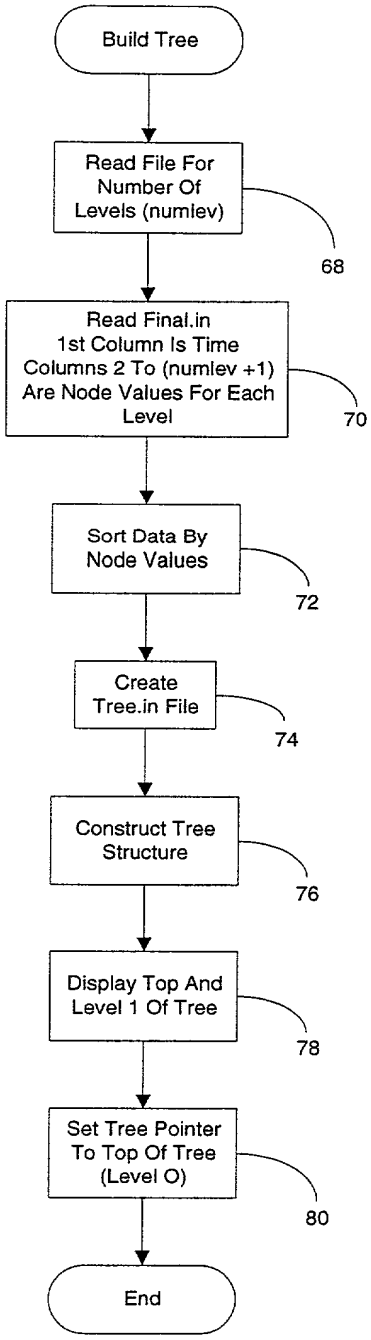

Build Tree
Read File For Number Of Levels (numlev)
68
Read Final.in 1st Column Is Time Columns 2 To (numlev +1) Are Node Values For Each Level
70
Sort Data By Node Values
72
Create Tree.in File
74
Construct Tree Structure
76
Display Top And Level 1 Of Tree
78
Set Tree Pointer To Top Of Tree (Level O)
80
End

Fig. 8

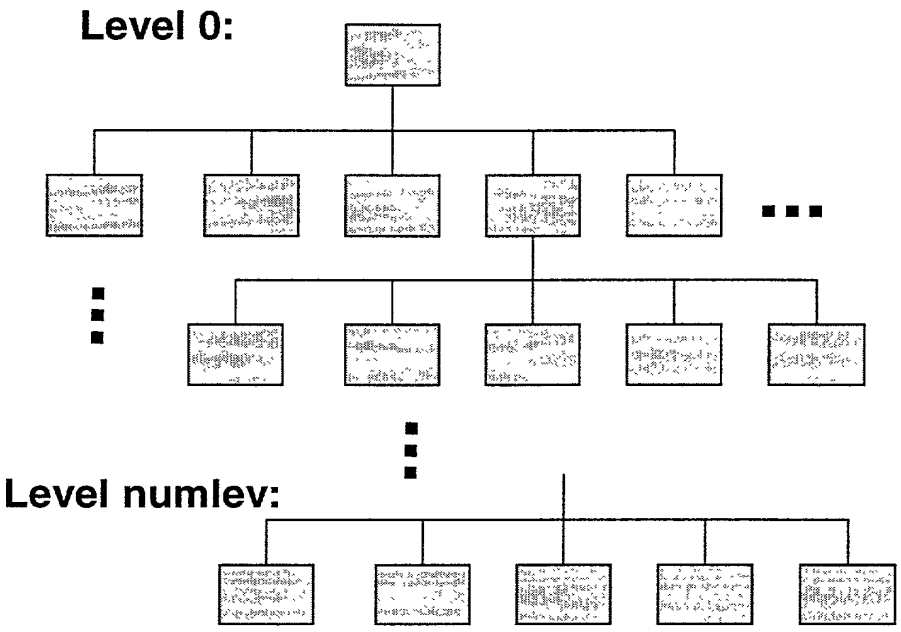


Fig. 9

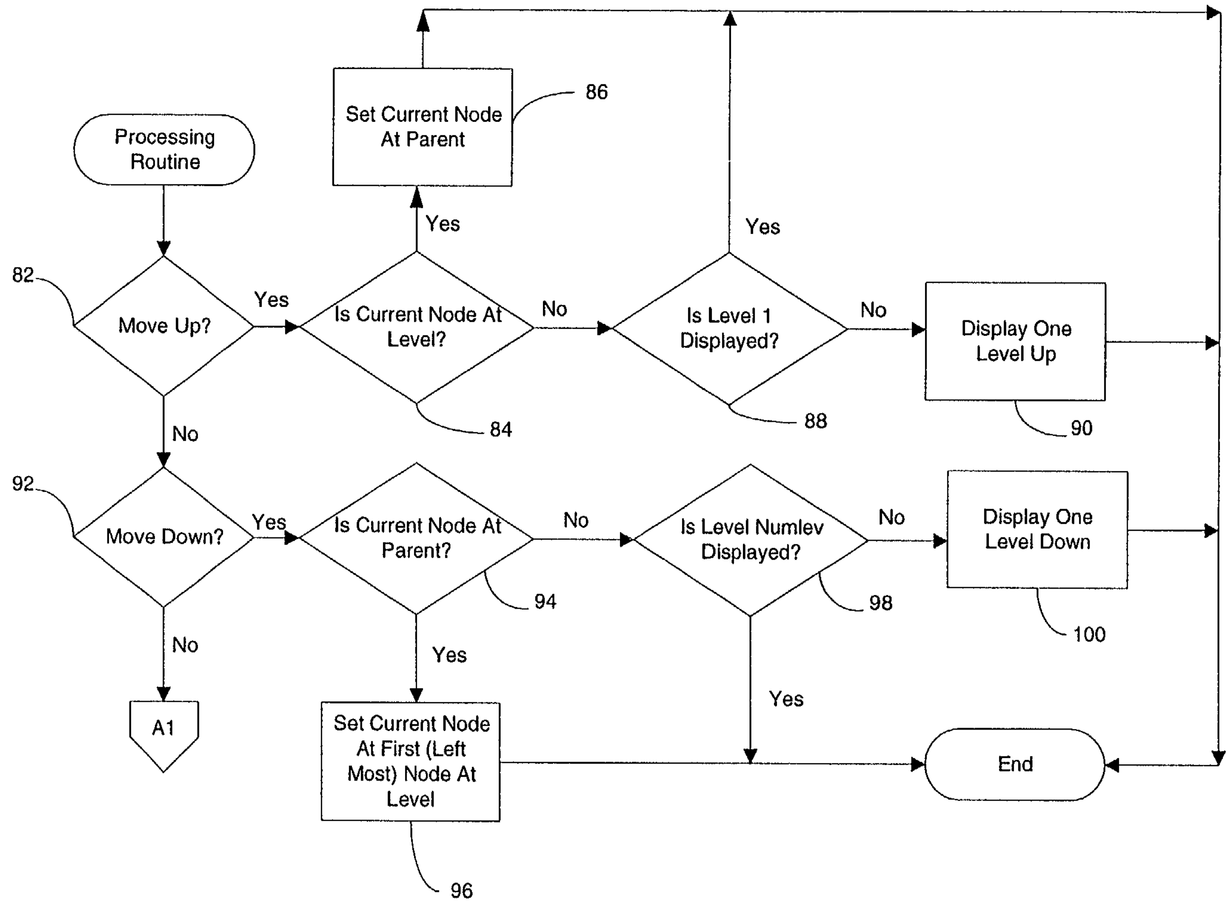

Processing Routine
82
Move Up?
Yes
No
Is Current Node At Level?
84
Yes
Set Current Node At Parent
86
No
Is Level 1 Displayed?
88
Yes
No
Display One Level Up
90
92
Move Down?
Yes
No
A1
Is Current Node At Parent?
94
Yes
Set Current Node At First (Left Most) Node At Level
96
No
Is Level Numlev Displayed?
98
Yes
No
Display One Level Down
100
End

Fig. 10a

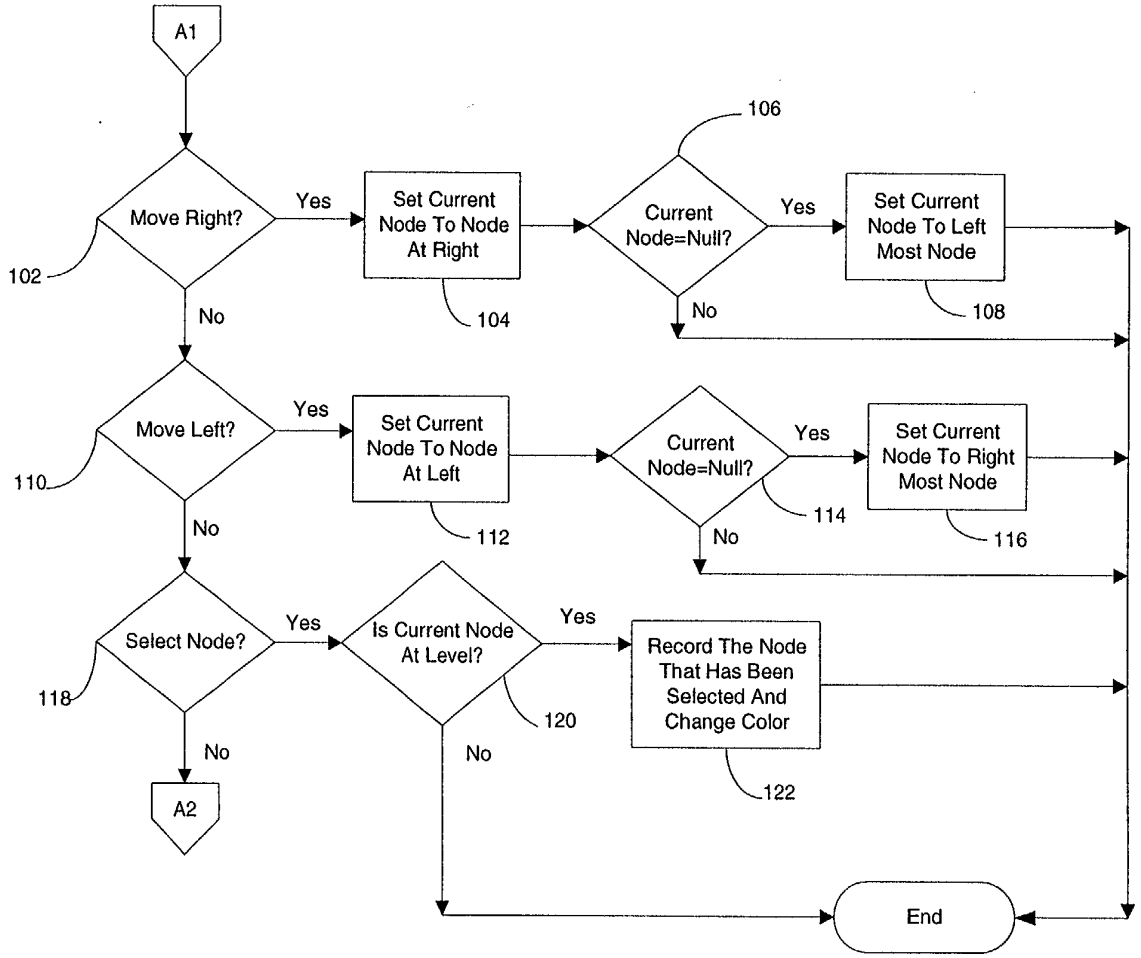

A1
Move Right?
Yes
Set Current Node To Node At Right
Current Node=Null?
Yes
Set Current Node To Left Most Node
106
102
104
108
No
Move Left?
Yes
Set Current Node To Node At Left
Current Node=Null?
Yes
Set Current Node To Right Most Node
110
112
114
116
No
Select Node?
Yes
Is Current Node At Level?
Yes
Record The Node That Has Been Selected And Change Color
118
120
122
No
No
A2
End

Fig. 10b

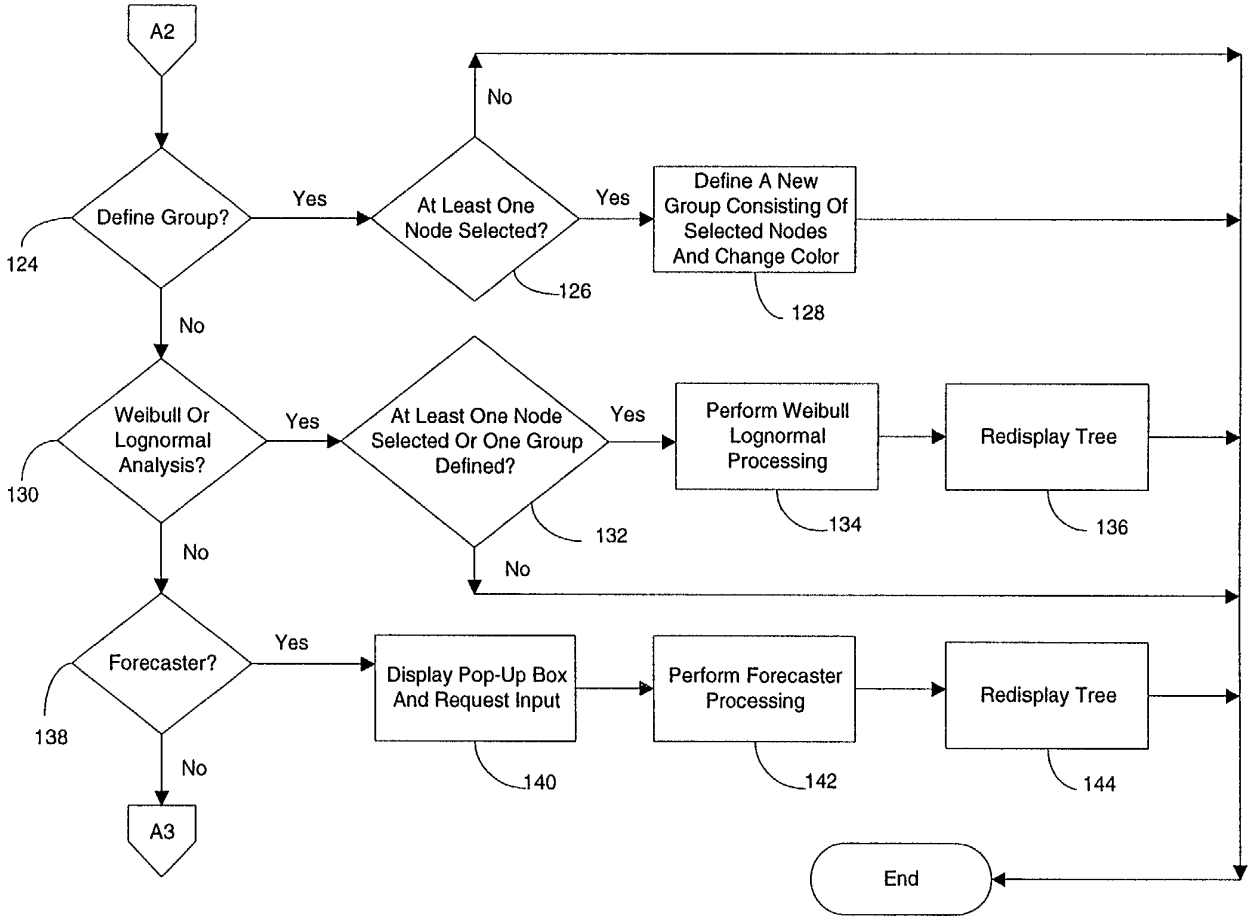

A2
Define Group?
124
Yes
At Least One Node Selected?
126
Yes
Define A New Group Consisting Of Selected Nodes And Change Color
128
No
No
Weibull Or Lognormal Analysis?
130
Yes
At Least One Node Selected Or One Group Defined?
132
Yes
Perform Weibull Lognormal Processing
134
Redisplay Tree
136
No
No
Forecaster?
138
Yes
Display Pop-Up Box And Request Input
140
Perform Forecaster Processing
142
Redisplay Tree
144
No
A3
End

Fig. 10c

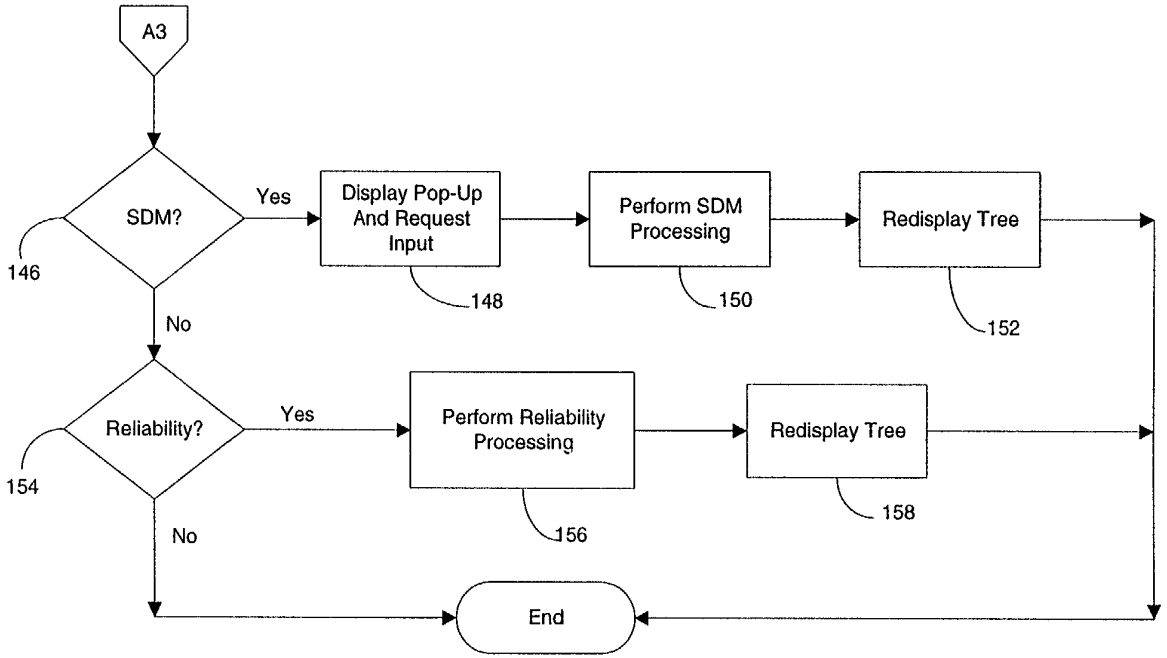

A3
SDM?
146
Yes
Display Pop-Up And Request Input
148
Perform SDM Processing
150
Redisplay Tree
152
No
Reliability?
154
Yes
Perform Reliability Processing
156
Redisplay Tree
158
No
End

Fig. 10d

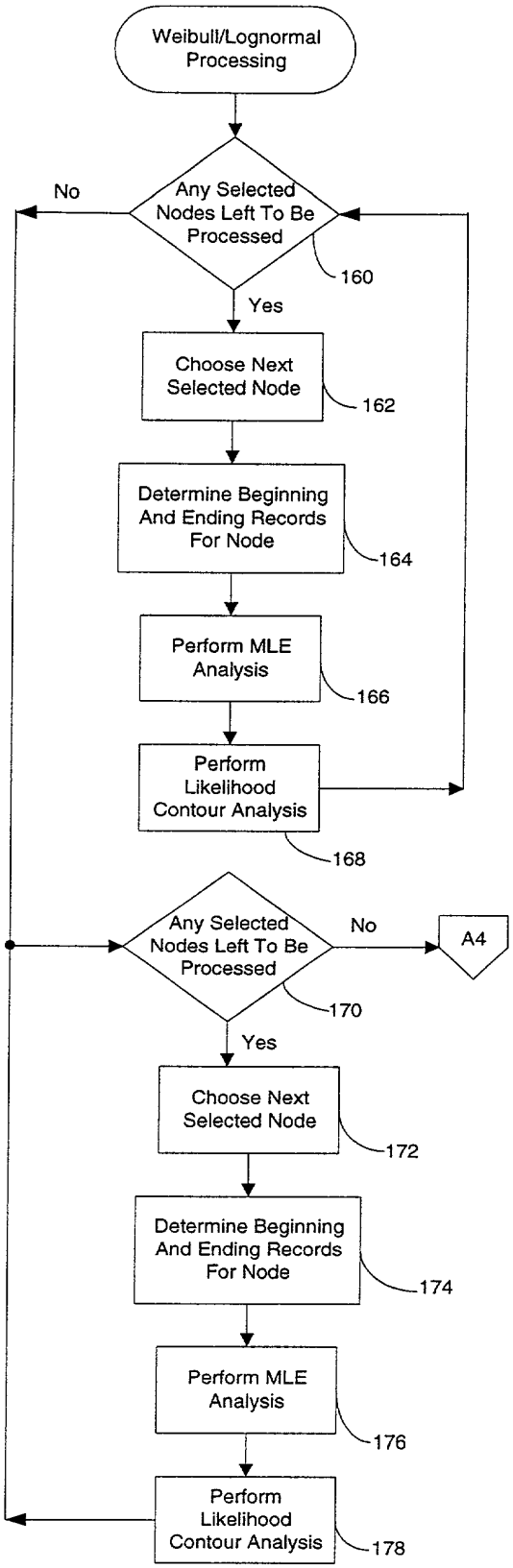

Weibull/Lognormal Processing
Any Selected Nodes Left To Be Processed
No
Yes
160
Choose Next Selected Node
162
Determine Beginning And Ending Records For Node
164
Perform MLE Analysis
166
Perform Likelihood Contour Analysis
168
Any Selected Nodes Left To Be Processed
No
A4
170
Yes
Choose Next Selected Node
172
Determine Beginning And Ending Records For Node
174
Perform MLE Analysis
176
Perform Likelihood Contour Analysis
178

Fig. 11a

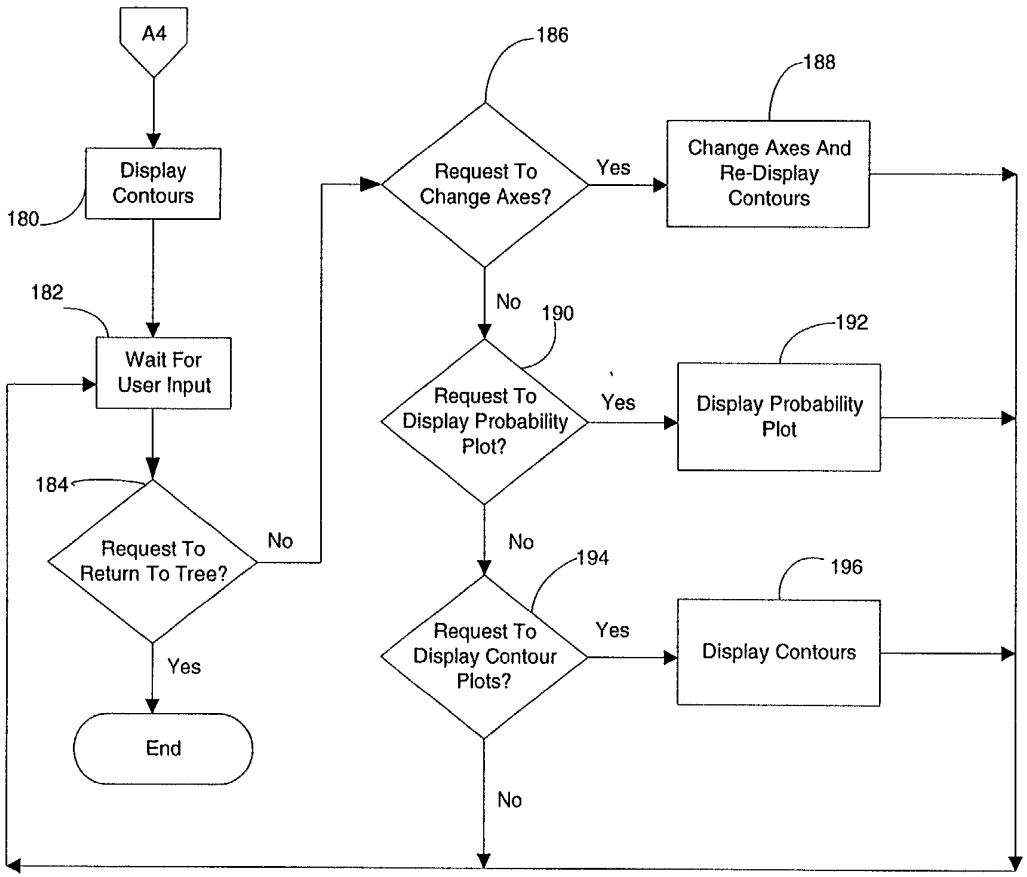


Fig. 11b

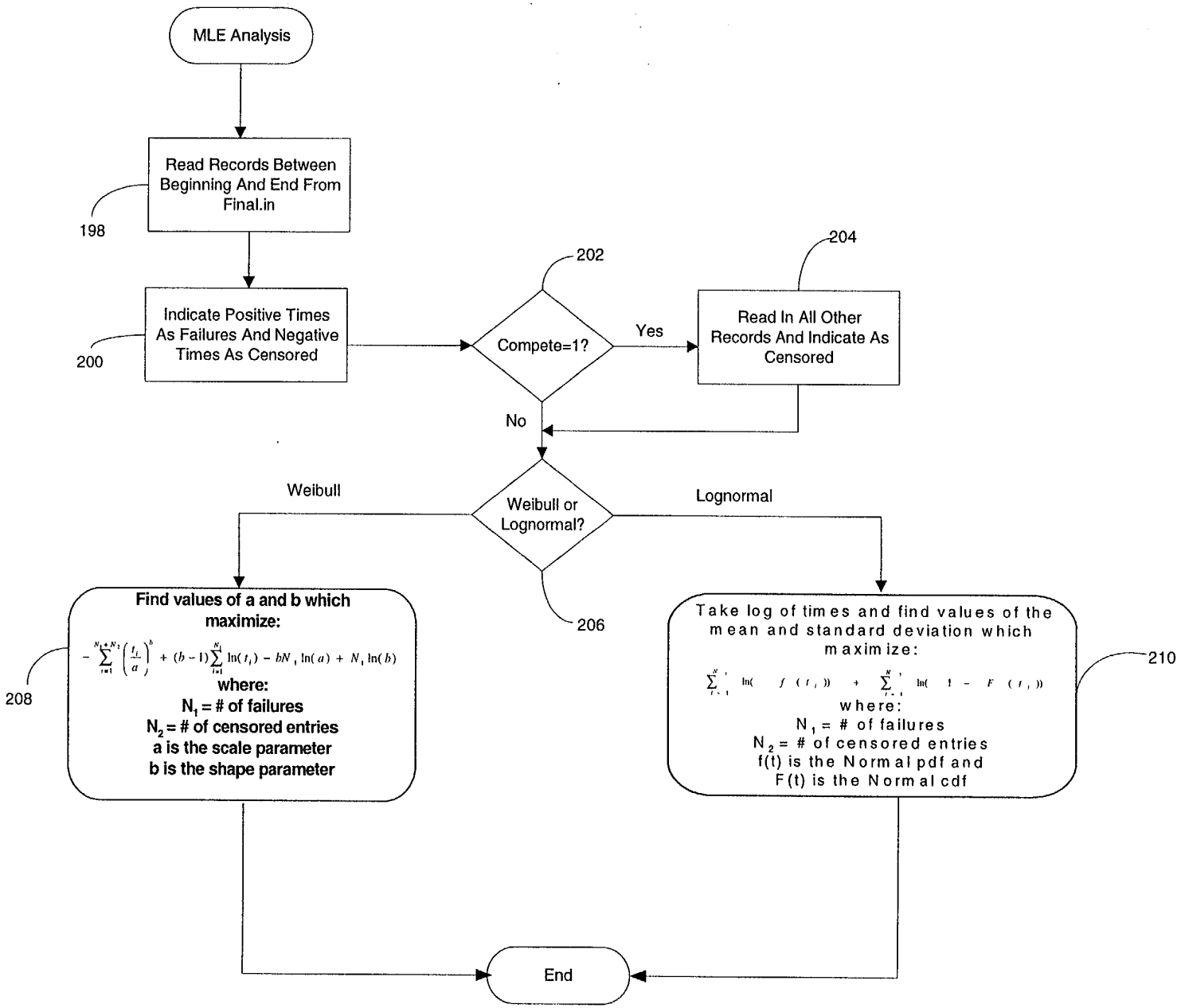


Fig. 12

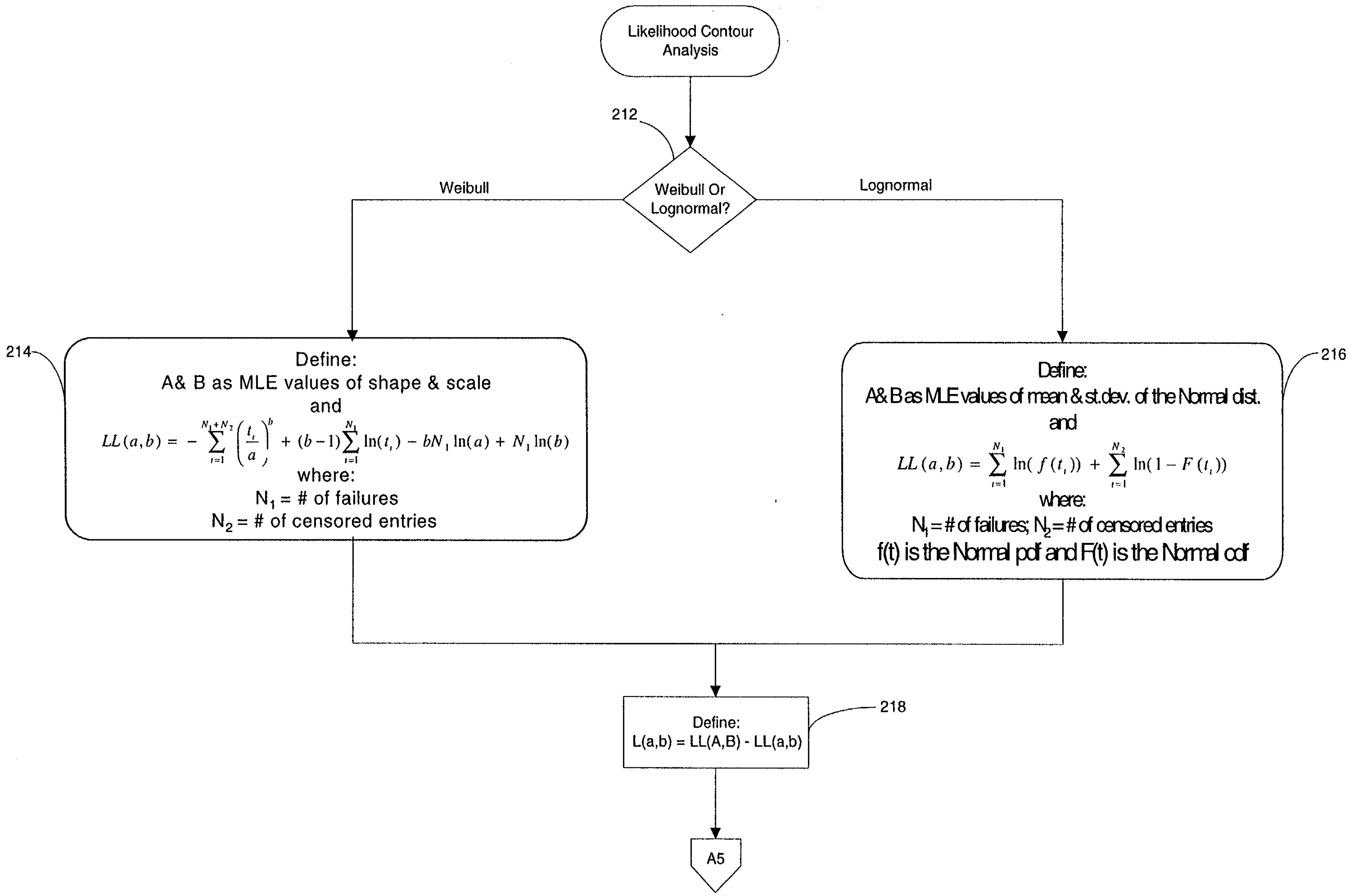

Likelihood Contour Analysis
212
Weibull Or Lognormal?
Weibull
Lognormal
214
Define:
A& B as MLE values of shape & scale
and
$LL(a,b) = -\sum_{i=1}^{N_1+N_2}\left(\frac{t_i}{a}\right)^b + (b-1)\sum_{i=1}^{N_1}\ln(t_i) - bN_1\ln(a) + N_1\ln(b)$
where:
N_1 = # of failures
N_2 = # of censored entries
216
Define:
A& B as MLE values of mean & st.dev. of the Normal dist.
and
$LL(a,b) = \sum_{i=1}^{N_1}\ln(f(t_i)) + \sum_{i=1}^{N_2}\ln(1-F(t_i))$
where:
N_1 = # of failures; N_2 = # of censored entries
f(t) is the Normal pdf and F(t) is the Normal cdf
218
Define:
L(a,b) = LL(A,B) - LL(a,b)
A5

Fig. 13a

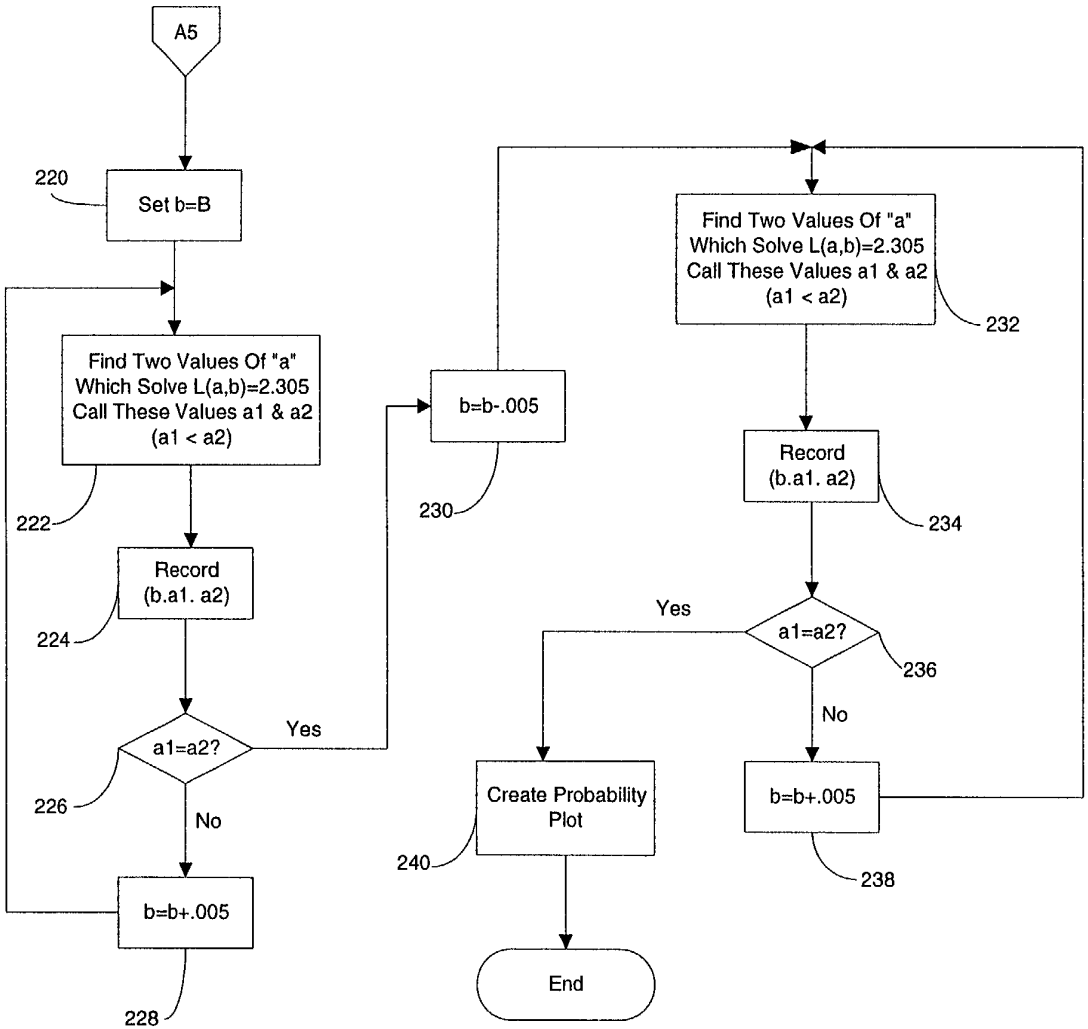


Fig. 13b

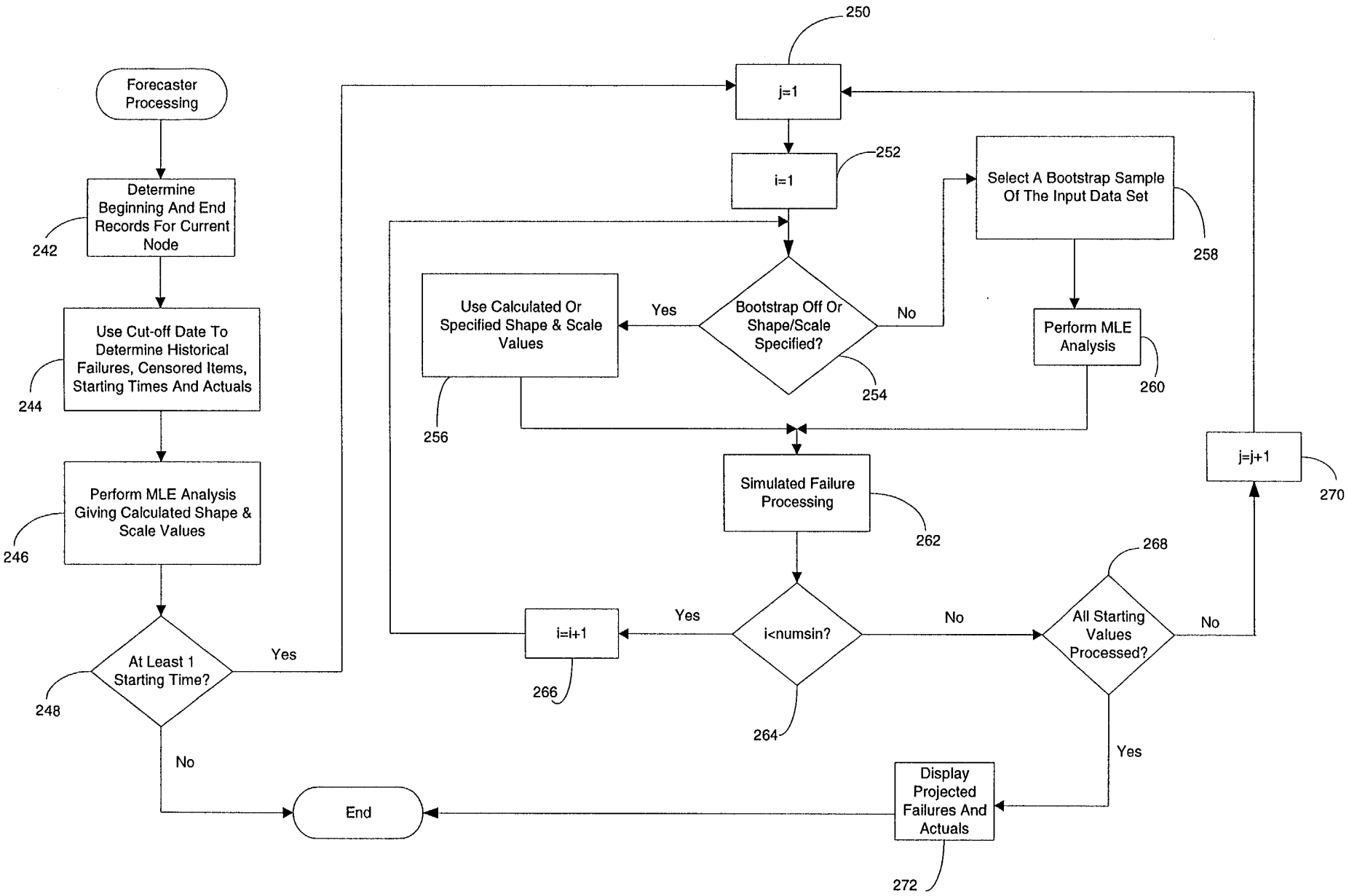


Fig. 14

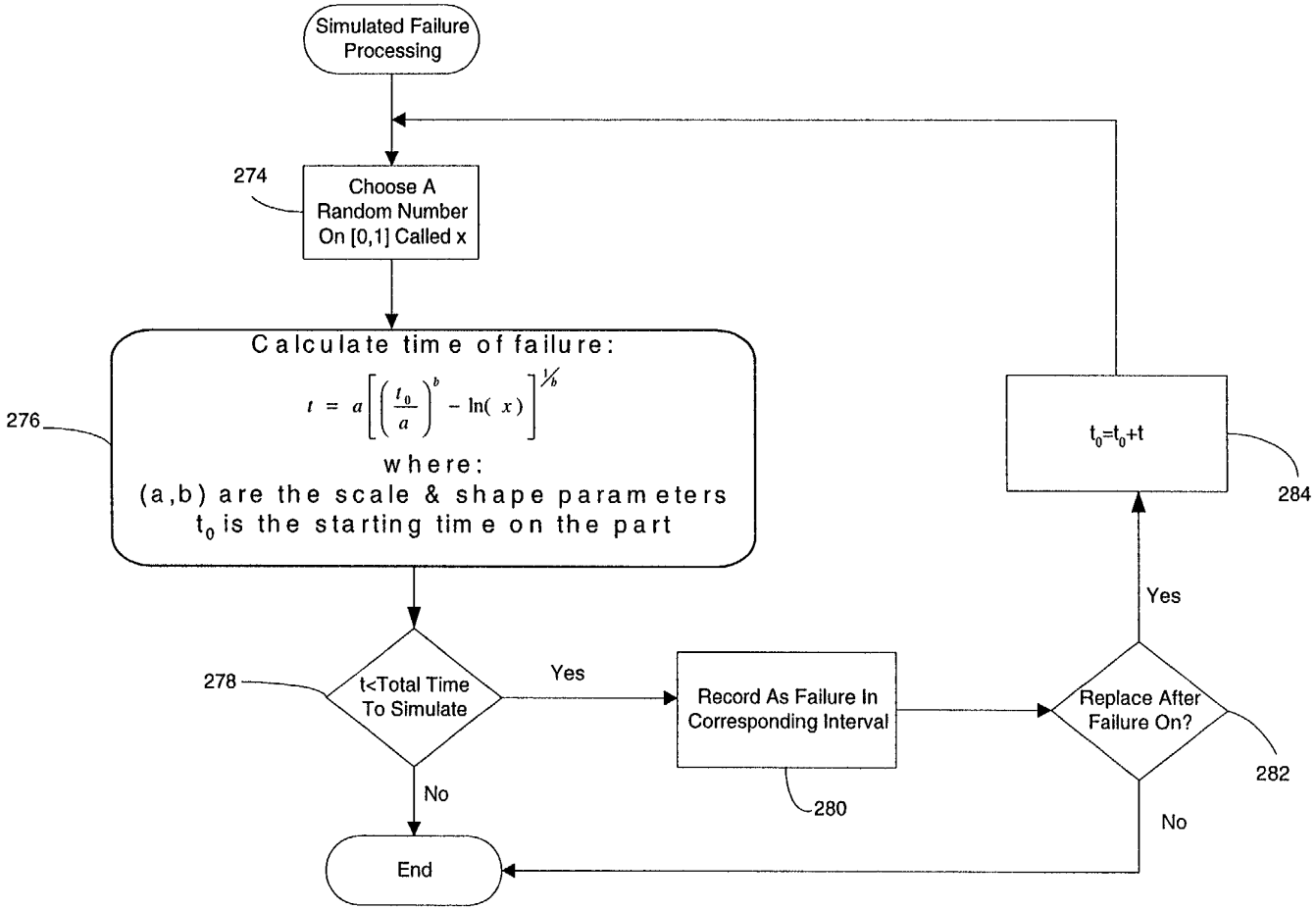

Simulated Failure Processing
274
Choose A Random Number On [0,1] Called x
Calculate time of failure:
$t = a\left[\left(\frac{t_0}{a}\right)^b - \ln(x)\right]^{1/b}$
where:
(a,b) are the scale & shape parameters
t_0 is the starting time on the part
276
278
t<Total Time To Simulate
Yes
No
Record As Failure In Corresponding Interval
280
Replace After Failure On?
282
Yes
No
$t_0=t_0+t$
284
End

Fig. 15

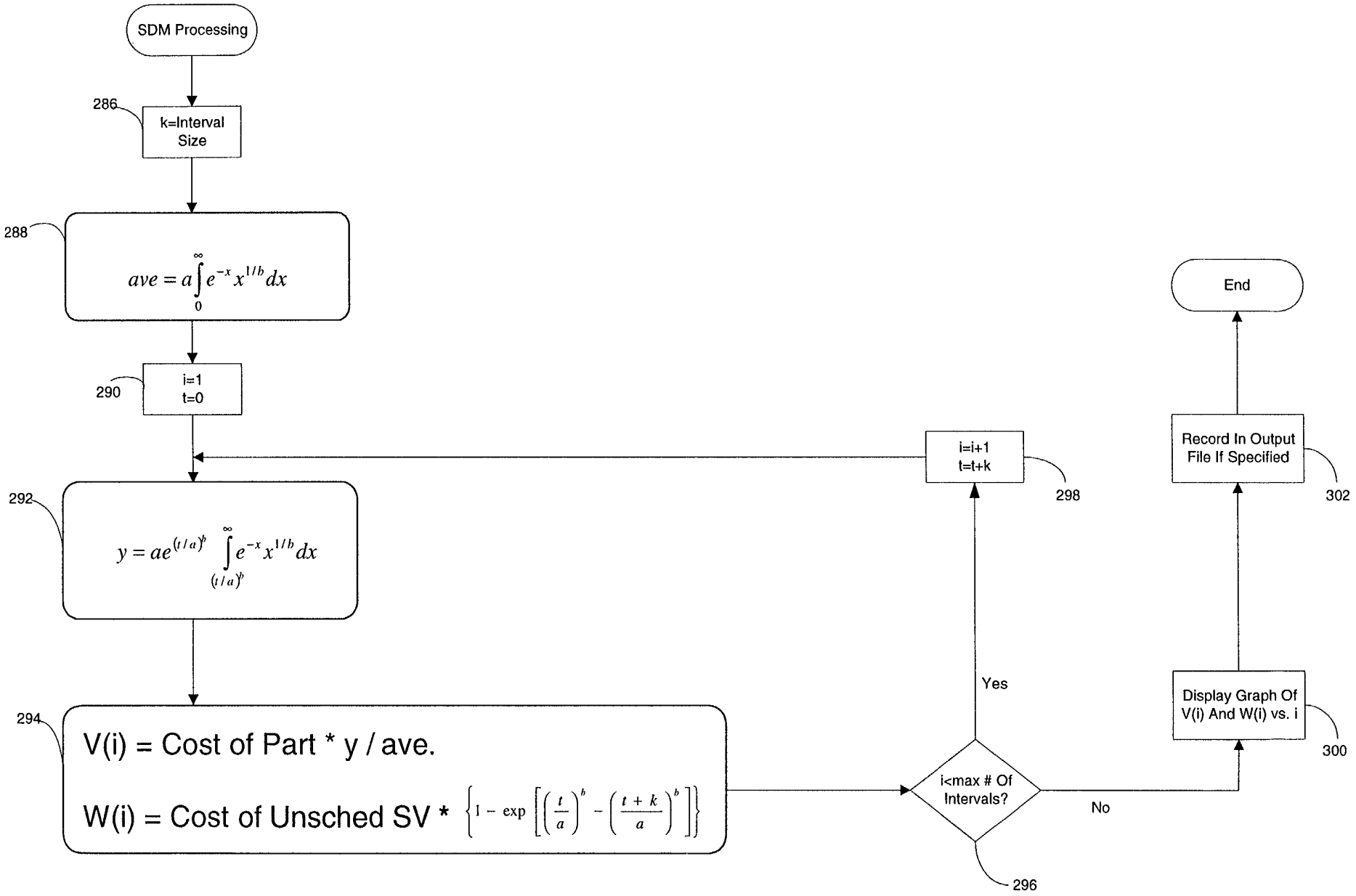

SDM Processing
286
k=Interval Size
288
$ave = a\int_0^\infty e^{-x} x^{1/b} dx$
290
i=1
t=0
292
$y = ae^{(t/a)^b} \int_{(t/a)^b}^\infty e^{-x} x^{1/b} dx$
294
V(i) = Cost of Part * y / ave.
W(i) = Cost of Unsched SV * $\left\{1 - \exp\left[\left(\frac{t}{a}\right)^b - \left(\frac{t+k}{a}\right)^b\right]\right\}$
i<max # Of Intervals?
296
Yes
No
i=i+1
t=t+k
298
Display Graph Of V(i) And W(i) vs. i
300
Record In Output File If Specified
302
End

Fig. 16

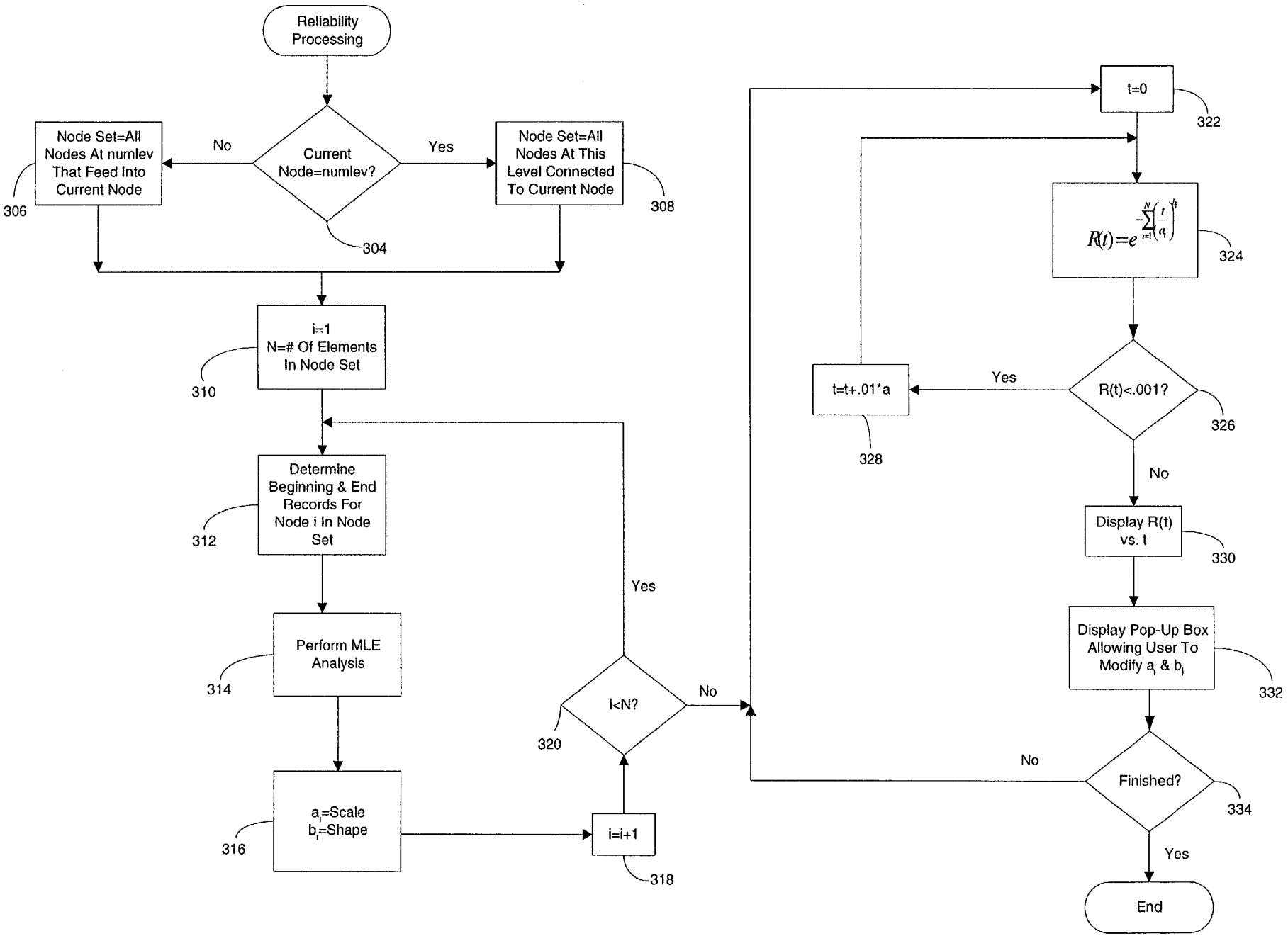


Fig. 17

Likelihood Contour Plot

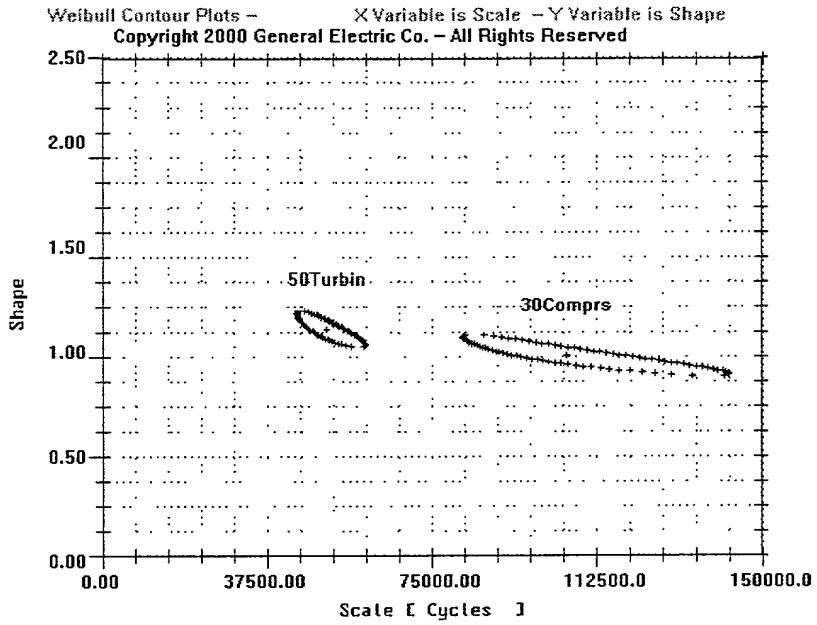


Fig. 18a

Probability Plot

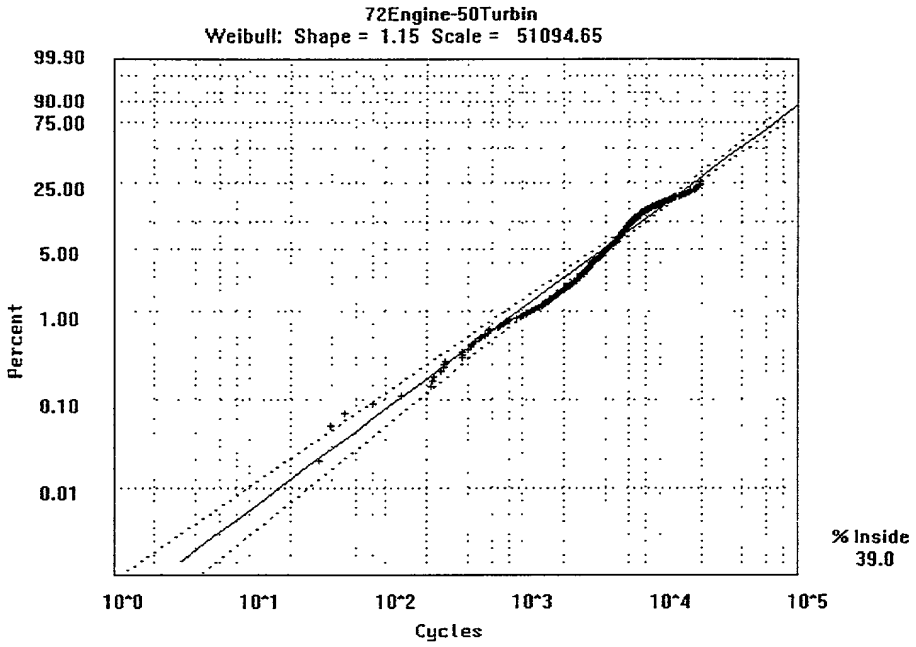


Fig. 18b

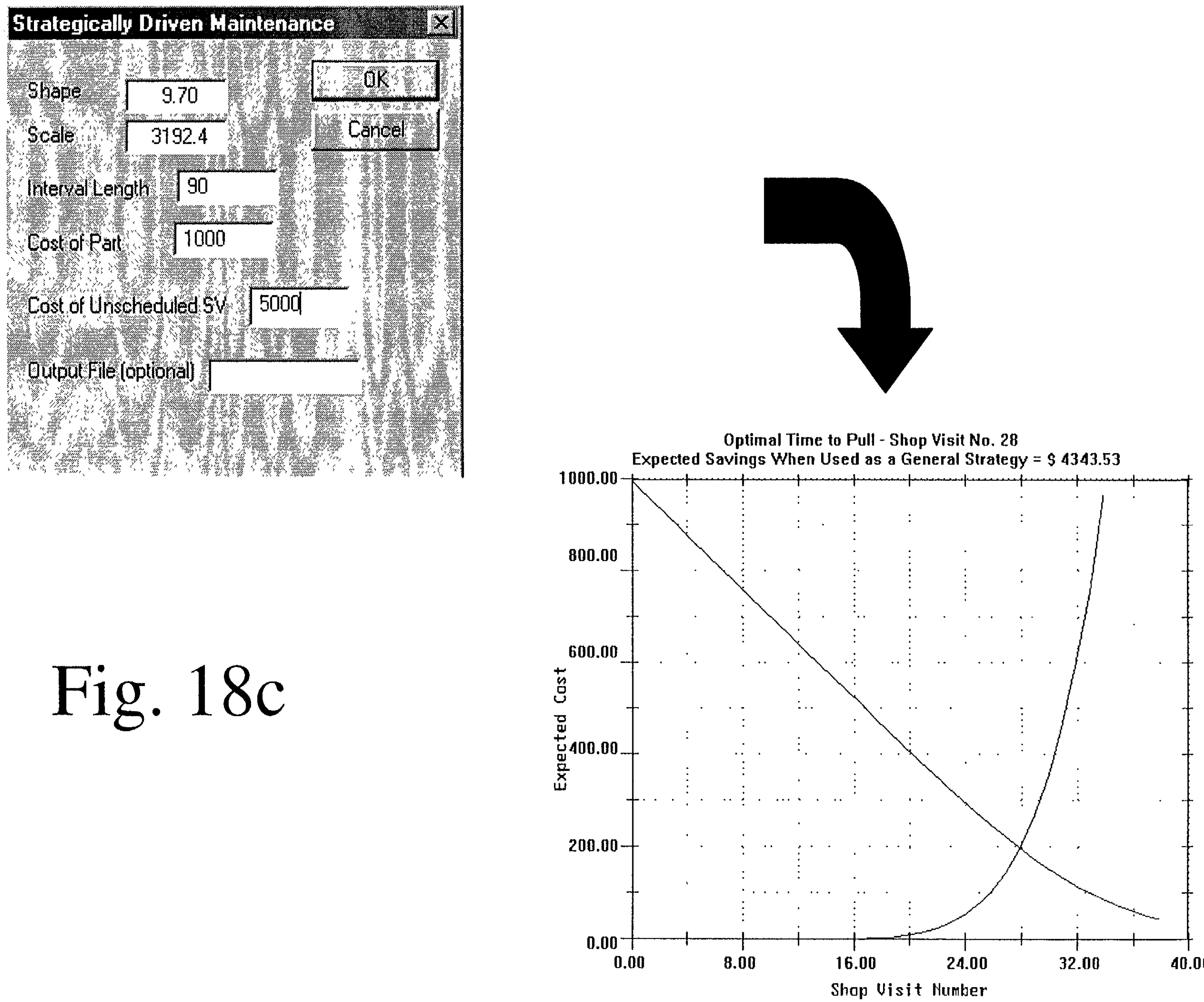

Strategically Driven Maintenance
Shape
9.70
Scale
3192.4
Interval Length
90
Cost of Part
1000
Cost of Unscheduled SV
5000
Output File (optional)
OK
Cancel
Optimal Time to Pull - Shop Visit No. 28
Expected Savings When Used as a General Strategy = $ 4343.53
Expected Cost
1000.00
800.00
600.00
400.00
200.00
0.00
0.00
8.00
16.00
24.00
32.00
40.00
Shop Visit Number

Fig. 18c

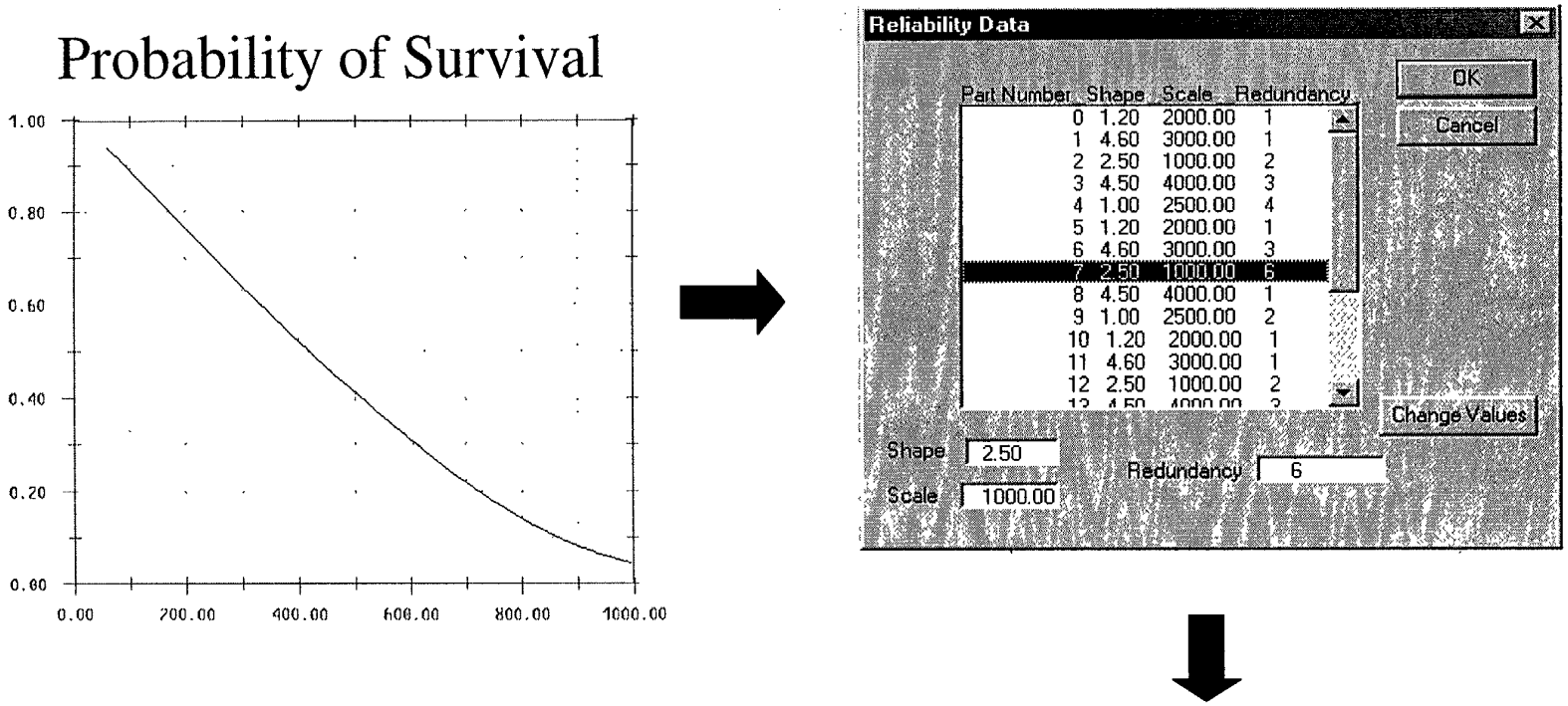

Probability of Survival
1.00
0.80
0.60
0.40
0.20
0.00
0.00
200.00
400.00
600.00
800.00
1000.00
Reliability Data
OK
Cancel
Part Number Shape Scale Redundancy
0 1.20 2000.00 1
1 4.60 3000.00 1
2 2.50 1000.00 2
3 4.50 4000.00 3
4 1.00 2500.00 4
5 1.20 2000.00 1
6 4.60 3000.00 3
7 2.50 1000.00 6
8 4.50 4000.00 1
9 1.00 2500.00 2
10 1.20 2000.00 1
11 4.60 3000.00 1
12 2.50 1000.00 2
Change Values
Shape 2.50
Redundancy 6
Scale 1000.00
1.00
0.80
0.60
0.40
0.20
0.00
0.00
200.00
400.00
600.00
800.00
1000.00

Fig. 18d

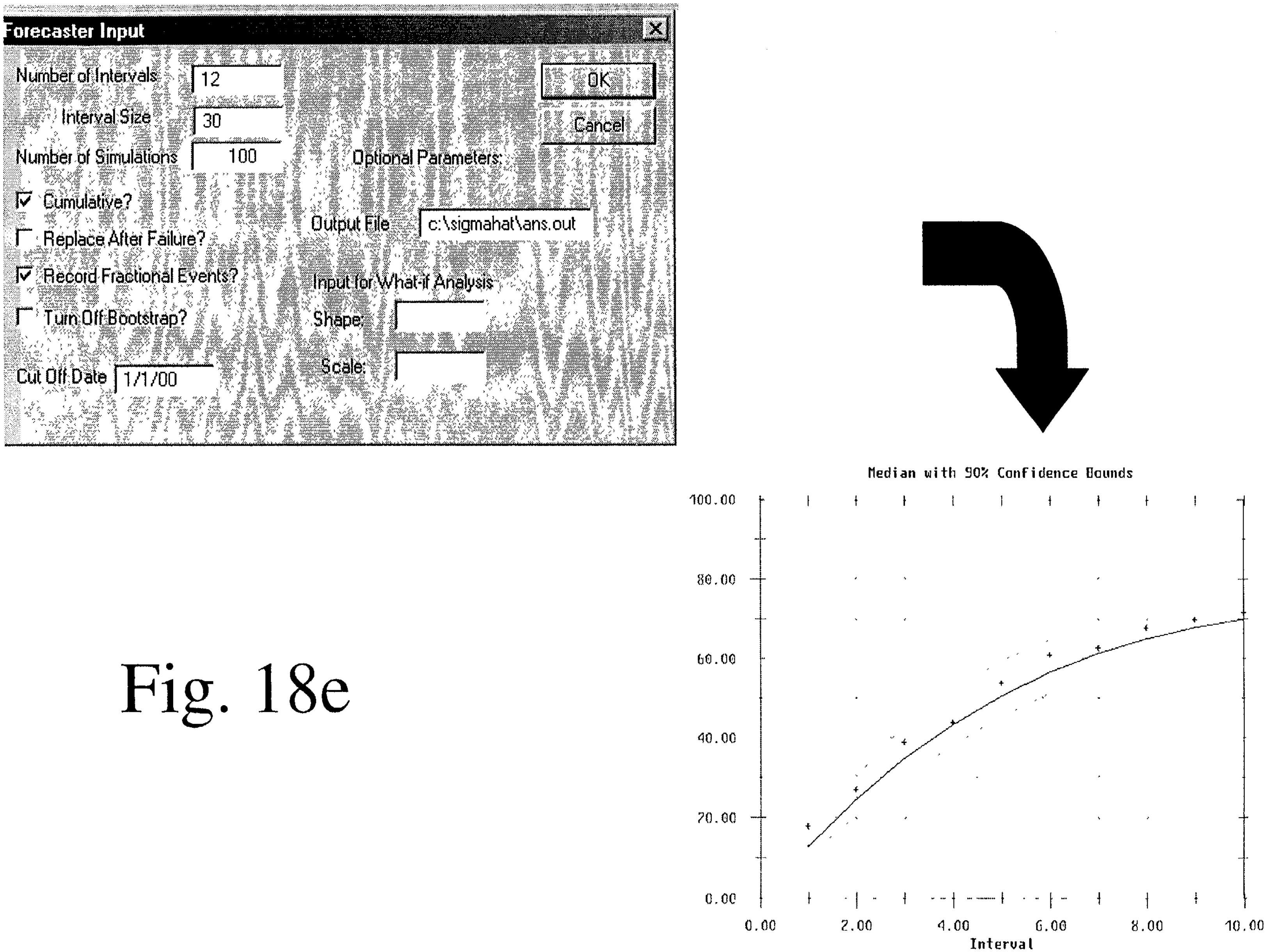

Forecaster Input
Number of Intervals
12
Interval Size
30
Number of Simulations
100
Cumulative?
Replace After Failure?
Record Fractional Events?
Turn Off Bootstrap?
Cut Off Date
1/1/00
OK
Cancel
Optional Parameters:
Output File
c:\sigmahat\ans.out
Input for What-if Analysis
Shape:
Scale:
Median with 90% Confidence Bounds
100.00
80.00
60.00
40.00
20.00
0.00
0.00
2.00
4.00
6.00
8.00
10.00
Interval

Fig. 18e

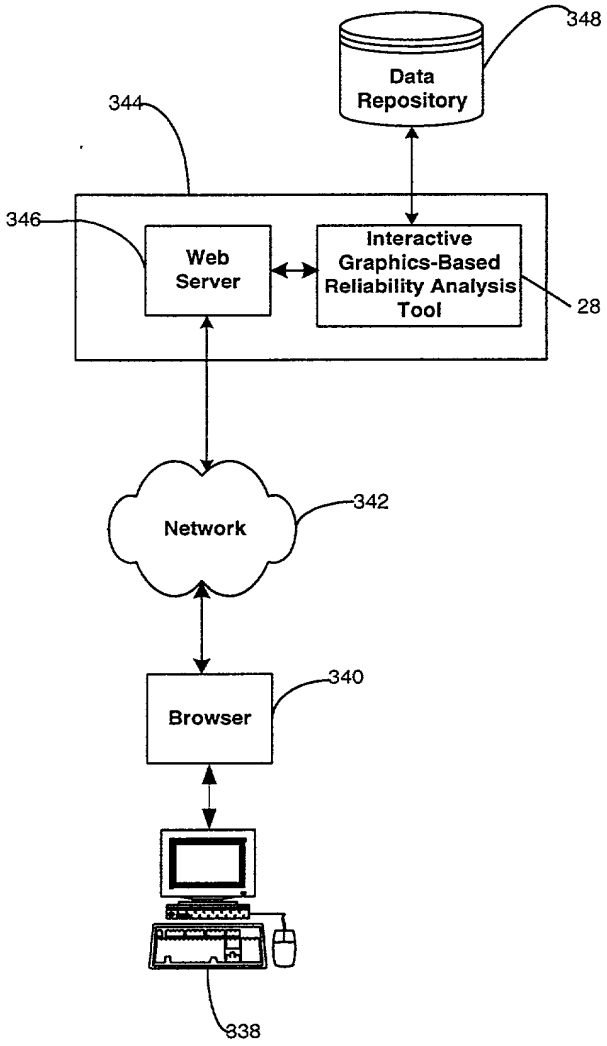

336
348
Data Repository
344
346
Web Server
Interactive Graphics-Based Reliability Analysis Tool
28
Network
342
Browser
340
338

Fig. 19

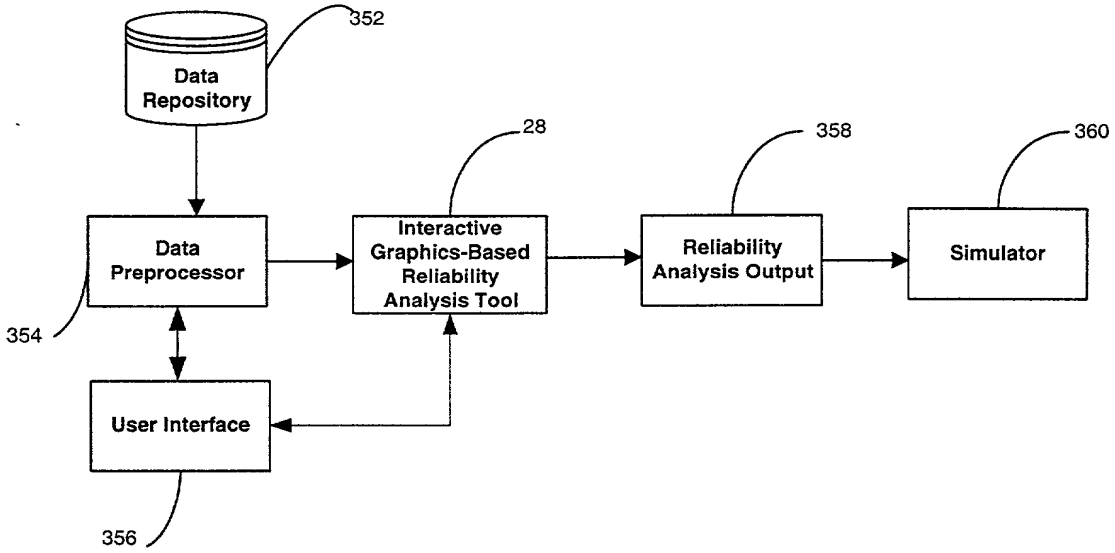

350
352
Data Repository
28
358
360
Data Preprocessor
Interactive Graphics-Based Reliability Analysis Tool
Reliability Analysis Output
Simulator
354
User Interface
356

Fig. 20

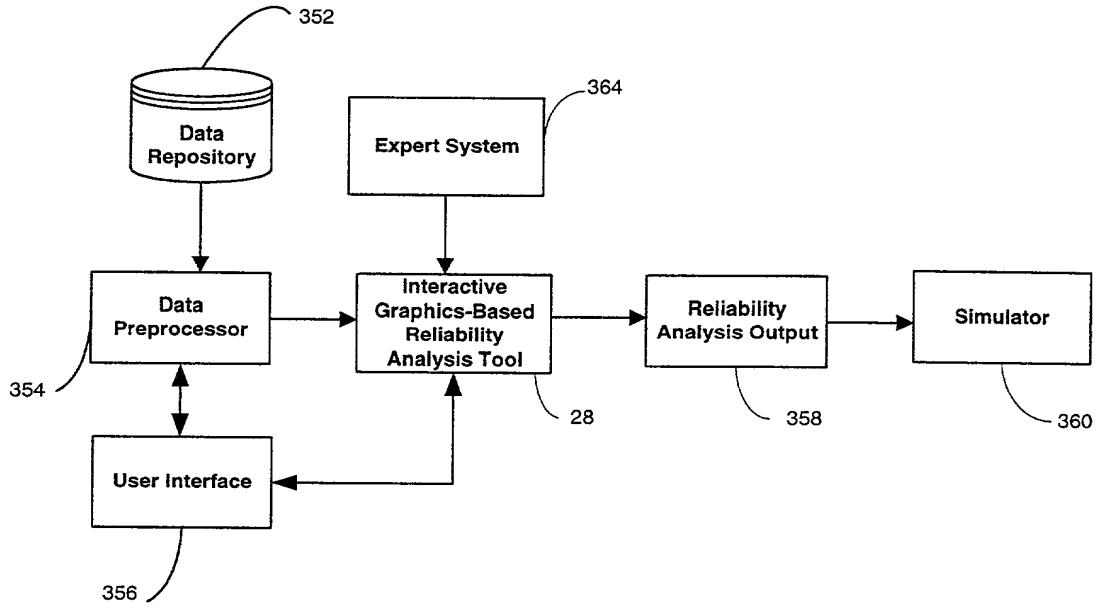

362
352
Data Repository
364
Expert System
Data Preprocessor
354
Interactive Graphics-Based Reliability Analysis Tool
28
Reliability Analysis Output
358
Simulator
360
User Interface
356

Fig. 21